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FLIGHT CONTROL SYSTEM: INVESTIGATION OF BEARING RETENTION BY USE OF ADHESIVE OR SEALANTS -

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TITLE

FLIGHT CONTROL SYSTEM: INVESTIGATION OF BEARING RETENTION BY USE OF ADHESIVES OR SEALANTS -

SUBMITTED UNDER

The tests described in this report were conducted between 4-8-63 and 10-30-63.

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GROUP: Chemistry Section, Engr. Test Lab.

REFERENCE: FZC-4-1263, EZM-12-104 A, B

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H. Z. Scott

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PURPOSE:

Installation of bearings using press fit methods requires very close machining tolerances, which are expensive to achieve and difficult to maintain. A further disadvantage of press fitting is that it tends to distort bearings, thus increasing breakaway torque of installed bearings to the point of rejection in some instances.

The purpose of these tests was to determine the feasibility of sealants or adhesives for installing bearings in steel and aluminum housing bores, thus reducing weight and tolerances required on bores, and in turn reducing cost and breakaway torque of installed bearings.

SUMMARY:

This report discusses the results of tests conducted on installation of bearings using sealants or adhesives. Tests were conducted to determine: the effect on breakaway torque; resistance to vibration under load; time and temperature properties under axial load; resistance to water, JP-4 fuel, and ethylene glycol; and the maximum thrust to remove bearings after each of the preceding tests. Methods of cleaning the bearing outer race were also studied.

These various tests were conducted in close coordination with the Design Group. The use of Loctite sealants, grades "A" and "B" proved to be entirely feasible for bearing installations in steel housings, but are not adequate for use in aluminum housings.

OBJECT:

To investigate the use of sealants and adhesives for bearing installation in steel and aluminum housing bores, subject to high and low temperature ranges, fluid exposures, and vibration forces.

DESCRIPTION OF MATERIALS:

Ball Bearings:		Source
GD P/N C-4-1263-3-1	Vendor P/N MKS4A	Fafnir Bearing Co.
GD P/N C-4-1263-25-1	Vendor P/N MKS25B	New Britain, Conn.

Materials used for housings:	
Steel 4130	MIL-S-6758
Aluminum 7075-T6	QQ-A-283

Sealants and Adhesives:	
Loctite "AA(V)", "A" and "B" Locquic N (primer)	Loctite Corp., Newington, Conn.
Epon 812 and 815	Shell Chemical Co., New York 20, N.Y.

Solvents used for immersion:	
JP-4 fuel	MIL-F-5624
Ethylene Glycol	Dow Chemical Co., Houston, Texas
Distilled Water	-------

DESCRIPTION OF TEST EQUIPMENT:

Vibration Test Equipment:

Vibration Shaker	MB Model C-10
Power Amplifier	MB Model T-66
Control Console	MB Model N-571
Accelerometer	Endevco Model 2735
Accel. Amplifier	Endevco Model 2616
Voltmeter	Ballantine Model 300
Strain Gauge	Budd Model C-6 (114)
SR-4 Box	Baldwin Type N

Instrumentation - Overall accuracy ±5% calibrated over 90 days against standards.

Maximum Thrust Test Equipment:

Baldwin Universal Test Machine - capacity 6000 lbs., accuracy ±1/2%

PROCEDURE:

All housing bores were manufactured by GD/FW shops as per Fig. 1 with 63 and 125 RMS surface finishes. All jigs had four holes except those tested for time-temperature properties and these had two holes.

Installation of Bearings:

Housing bores were measured with I.D. micrometers and sizes were scribed by each hole. Bores were cleaned by wiping them with methyl ethyl ketone (MEK) and vapor degreasing with stabilized trichloroethylene (Permachlor). All bearings were checked per FZC-4-1263* for breakaway torque before installation. Bearing outer races were wiped with MEK and allowed to air dry.

Housings and bearings were wetted with Locquic N primer and allowed to air dry for 30 minutes. Sealant was applied to housing bore and bearing outer race with a camel hair brush and bearing was slip fitted into housing bore. The inter face line of bearing and housing was filled with additional sealant and allowed to cure at room temperature for 24 hours.

After 24-hour cure period, all installed bearings were checked per FZC-4-1263 for breakaway torque.

* Reference MIL-B-7949

Vibration Test:

The vibration procedure used in this bearing test was in accordance with FZM-12-104A, Table III and Figure 21*

The bearings were loaded with 100-lb thrust loads applied in the opposite direction to the shoulder of the bearing mounting jig. Tension bolts and reaction columns were used to apply the loads and are shown in Figure 22. Strain gages attached to the bolts were monitored on an SR-4 box for load indication. The entire assembly was mounted on the shaker as shown in Figure 23 and subjected to vibration in the vertical and radial axes. The assembly was tested in only one radial axis since the bearings were symmetrical in that axis.

A resonant search was conducted in each axis and no resonance was found. Each bearing setup was cycled for 180 minutes at room temperature, 45 minutes at 270°F, and 45 minutes at -65°F in the two axes mentioned above. The cycling rate was logarithmic over a frequency range of 5 to 500 cps with a complete cycle period of 15 minutes. The amplitudes of vibration were as follows:

5 to 10 cps - 0.080 inches double amplitude displacement
10 to 15 cps - ±0.41 G - peak
15 to 65 cps - 0.036 inches double amplitude displacement
65 to 500 cps - ±10 G - peak.

Time-Temperature Test:

Two-hole jigs with 63 and 125 RMS surface finish were used; bearings were installed as previously described. After the 24-hour cure period an axial load of 100 pounds was applied on the bearing in the opposite direction from housing shoulder. The jigs were then heated to 270°F and held at this temperature for 8 hours under load. Bearings were checked per FZC-4-1263 for breakaway torque and then subjected to -65°F under 100 pounds axial load for 12 hours. Jigs were removed from cold box, axial load removed, and bearings were again checked for breakaway torque.

At the end of this test the bearings were subjected to 100% thrust load, half of them at -65°F, and the remaining half at 270°F.

Immersion Test:

Jigs with installed bearings were completely immersed in JP-4 fuel, ethylene glycol, and distilled water, then placed in an oil bath maintained at 180°F for 36 hours. At the end of the 36-hour period jigs were removed from the test fluids and tested for 100% thrust within 2 hours after they were removed.

Maximum Thrust Test:

Bearings were installed in several four-hole jigs using 63 and 125 RMS surface finishes and two different bearing sizes for room temperature

* Reference Supplemental Sheet S-1

controls. Maximum thrust loads were applied on the bearings in the opposite direction from the housing shoulder until the bearing came out or was destroyed. Thrust loads were applied with Baldwin Universal test machines.

Special Cleaning Methods:

Three special cleaning methods were used for cleaning the outer race of bearings. They were as follows:

A. Sil Sol (special solvent for silicones)

1. Clean outer race with MEK.
2. Wipe outer race with Sil Sol.
3. Air Dry.

B. Acid

1. Repeat steps 1 and 2 of A.
2. Wipe chromic acid solution on outer race and let stand for 2 minutes.
3. Rinse with tap water.
4. Air Dry.

Chromic Acid Solution
Water - 30 parts by weight
Sulfuric Acid - 10 parts by weight (66° Be)
Sodium Dichromate - 4 parts by weight.

C. Sand Blast

1. Repeat steps 1 and 2 of A.
2. Lightly sand blast outer race.
3. Air clean bearing.

RESULTS:

Functional Test: (Steel Housings)

All bearings installed in jigs with Loctite "A" were checked per FZC-4-1263 for breakaway torque before installation and only those bearings passing this specification were used. After installation 15 of 20 press-fitted bearings would not pass the requirements for breakaway torque. Sixty-six bearings were installed using Loctite "A" and slip fitting, and all passed the requirements on breakaway torque after installation.

Vibration Test: (Steel Housings)

A. Loctite "A"

Four separate jigs were tested combining two different finishes, four bore sizes, and two bearing sizes. Of the four jigs tested

one jig did not complete all the test cycles. This jig had a 63 RMS finish, and 0.7500 in. dia. bearings. It completed the room temperature and 270°F cycles, but the three bearings installed with Loctite "A" failed to hold 100-lb loads at -65°F. (Reason for this failure outlined in Para. 4 of the Discussion.) The three remaining jigs completed all the test cycles without any failures.

B. Loctite "B"

Jigs used in Loctite "A" test were cleaned and reused for this test. Two press fit bearings would not hold 100-pound axial load.

Maximum axial thrust for bearings after completing vibration tests are listed in Table III.

Time-Temperature Test: (Steel Housings)

No problems were encountered with either Loctite "A" or "B" during the 8 hours at 270°F and 12 hours at -65°F, and axial loads of 100 pounds using steel housings. Maximum thrust loads at -65°F and 270°F are listed in Tables IV and V.

Immersion Test: (Steel Housings)

Neither Loctite "A" or "B" showed any detrimental effects following 36 hours immersion at 180°F in distilled water, JP-4 fuel, or ethylene glycol. Maximum thrust loads are tabulated in Tables VI, VII, VIII and IX.

100% Thrust Test: (Steel Housings)

Average maximum thrust loads shown in Tables I and II show that a 125 RMS surface finish with an 0.003 inch oversize hole produce the best retention using Loctite "A" and "B" sealants with normal cleaning procedures. These results are also comparable to press-fitted installations.

Special Cleaning Test: (Steel Housings)

The results of special cleaning methods listed in Table X show that 100% thrust can be greatly improved by acid cleaning or sand blasting bearing outer races.

Test in Aluminum Housings:

Steel bearings could not be satisfactorily retained in 7057-T6 aluminum housing bores at 270°F using Loctite "AA(V)", "A", and "B" sealants. Steel bearings installed in housing bores, 0.001", 0.002", and 0.003" oversize with these three Loctite sealants and tested under 100 lb and 50 lb axial loads pulled out of the bores when going from room temperature to 270°F. It was also

determined that these Loctite sealants cure slower in Locquic N treated 7075-T6 bores than in 4130 steel bores treated in the same manner.

Due to above results no other tests were conducted in aluminum housing bores.

DISCUSSION:

A list of twelve possible sealants and adhesives were submitted to be tested in this program. Loctite "A" and "B" proved to be the most suitable sealants for bearing installation.

Two low viscosity Epons, 812 and 815, were studied. Both of these materials were extremely difficult to apply and had short pot lives of 15 minutes; therefore, these two adhesives were disregarded for use in bearing installation.

The use of sealants greatly reduced the breakaway torque on installed bearings as compared to press-fitted installations. Of twenty bearings installed in press fit housing bores which met tolerance requirements, fifteen bearings failed to meet FZC-4-1263 specifications on breakaway torque. Sixty-six bearings were slip-fit installed using Loctite "A" and all meet the breakaway torque requirements.

Vibration tests on jigs using Loctite "A" or "B" had no noticeable effect on the installations. One of the first jigs layed-up with Loctite "A" did not complete the test. It is believed that the failure of this jig was due to improper installation of the bearings. The bearings were installed using the "wicking action" of the sealant, and the outer race and housing bore were not properly wetted with sealant during installation.

Some difficulty was experienced with the curing of Loctite "B" in steel housings. The original Locquic N primer used with Loctite "A" had been exhausted and laboratory supplies of Locquic N that was past its expiration date was used with the Loctite "B". A new supply of Locquic N was received and no further problems were encountered with the use of Loctite "B".

Housing jigs used with Loctite "A" were cleaned and reused with Loctite "B". Maximum thrust was greatly decreased in some of the re-installed press fit bores, while Loctite "B" re-installations showed some increase in maximum thrust over the original using Loctite "A". (Loctite "A" is stronger than "B", according to vendor's literature.)

Temperatures ranging from -65°F to 270°F has little effect on Loctite "A" or "B" when used with steel housings. Maximum

average retention at 270°F was lower than specimens tested at room temperature, while bearings tested at -65°F had greater retention thrusts than room temperature tests.

The three fluids JP-4 fuel, ethylene glycol, or distilled water had no noticeable effects on either Loctite "A" or "B".

A study of Tables I through X indicates that a maximum retention thrust using normal cleaning methods can be obtained with Loctite "A" or "B" in steel housings, with a 125 RMS surface finish and a 0.003 ±0.001 in. oversize housing bore. If the average maximum thrust values listed in Tables I and II are not great enough they can be increased by either acid cleaning or by sand blasting the outer race of the bearings.

Installing bearings with steel races in aluminum housings is not feasible. Due to the difference in coefficients of thermal expansion between steel and aluminum, steel bearings cannot be retained in aluminum housing bores when heated to 270°F using normal installation procedures. Bearings can be retained in aluminum housings at 270°F by heating the housing to 270°F and installing a cool bearing (75°±3°F) and then curing the sealant at 250° to 270°F, but when housing and bearing are cooled to room temperatures and below, the bearing inner race cannot be turned with the hands. Also, due to the above mentioned physical properties it is not feasible to press-fit install steel bearings in aluminum housings.

CONCLUSION:

Laboratory tests conducted and described herein show that sealants can be used to install steel bearings in steel housing bores with greatly reduced tolerances on housing bores, and at the same time improving breakaway torque of installed bearings.

These tests also show that Loctite sealant installations cannot be used with aluminum housing bores and steel bearings.

TABLE I

AVERAGE 100% THRUST LOADS OF BEARINGS INSTALLED WITH LOCTITE "A" IN STEEL BORE HOUSING HOLES WITH 63RMS AND 125 RMS FINISHES

(Tested at 75°F ±3°)

Bearing Size (inches)	Finish (RMS)	Oversize (inches)	100% Load (pounds)
0.7500	63	Press fit	943
0.7500	125	Press fit	701
0.7500	63	0.001	401
0.7500	125	0.001	685
0.7500	63	0.002	660
0.7500	125	0.002	550
0.7500	63	0.003	670
0.7500	125	0.003	804
2.3130	63	Press fit	644
2.3130	125	Press fit	680
2.3130	63	0.001	407
2.3130	125	0.001	666
2.3130	63	0.002	637
2.3130	125	0.002	940
2.3130	63	0.003	543
2.3130	125	0.003	1088

Load Rate 800#/minute

TABLE II

AVERAGE 100% THRUST LOADS OF BEARINGS INSTALLED WITH LOCTITE "B" IN STEEL BORE HOUSING HOLES WITH 63 RMS AND 125 RMS FINISHES

(Tested at 75°F ±3°)

Bearing Size, Dia. - Inches	Finish, RMS	Hole Oversize, Inches	100% Load, Pounds
0.7500	63	Press Fit	253
0.7500	125	Press Fit	535
0.7500	63	0.001	676
0.7500	125	0.001	643
0.7500	63	0.002	640
0.7500	125	0.002	480
0.7500	63	0.003	551
0.7500	125	0.003	590
0.7500	63	0.004	-
0.7500	125	0.004	931
2.3130	63	Press Fit	324
2.3130	125	Press Fit	641
2.3130	63	0.001	1237
2.3130	125	0.001	1466
2.3130	63	0.002	1041
2.3130	125	0.002	1445
2.3130	63	0.003	1327
2.3130	125	0.003	1483
2.3130	63	0.004	-
2.3130	125	0.004	1472

Load rate 800#/minute

TABLE III
100% THRUST LOAD OF BEARINGS INSTALLED IN STEEL HOUSING BORES AFTER COMPLETING VIBRATION TESTS
(Tested at 75°F ±3°)

Bearing Size, Dia. -Inches	Type Loctite	Housing Surface Finish (RMS)	Hole Oversize, (inches)	100% Load, Pounds
0.7500	-	63	Press Fit	No Test -
0.7500	A	63	0.001	Bearings
0.7500	A	63	0.002	failed in
0.7500	A	63	0.003	vibration
0.7500	-	63	Press Fit	571
0.7500	B	63	0.001	442
0.7500	B	63	0.002	881
0.7500	B	63	0.003	735
0.7500	-	125	Press Fit	500
0.7500	A	125	0.001	1290
0.7500	A	125	0.002	560
0.7500	A	125	0.003	1040
0.7500	-	125	Press Fit	Failed in vib.
0.7500	B	125	0.001	519
0.7500	B	125	0.002	414
0.7500	B	125	0.003	613
2.3130	-	63	Press Fit	820
2.3130	A	63	0.001	950
2.3130	A	63	0.002	680
2.3130	A	63	0.003	615
2.3130	-	63	Press Fit	255
2.3130	B	63	0.001	920
2.3130	B	63	0.002	465
2.3130	B	63	0.003	695
2.3130	-	125	Press Fit	1145
2.3130	A	125	0.001	335
2.3130	A	125	0.002	595
2.3130	A	125	0.003	620
2.3130	-	125	Press Fit	Failed in vib.
2.3130	B	125	0.001	735
2.3130	B	125	0.002	820
2.3130	B	125	0.003	1725

Load Rate 800#/minute

TABLE IV

100% THRUST LOADS OF BEARINGS INSTALLED WITH LOCTITE "A" IN STEEL BORE HOUSING HOLES AND TESTED AT 270°F AND -65°F

Bearing Size (inches)	Finish (RMS)	Temperature °F	Oversize (inches)	100% Load Pounds
0.7500	63	270	0.003	240
0.7500	125	270	0.004	175
2.3130	63	270	0.001	340*
2.3130	125	270	0.001	970
2.3130	63	270	Press fit	1760
0.7500	125	-65	Press fit	1615
0.7500	63	-65	0.001	840
0.7500	125	-65	0.001	330
2.3130	63	-65	0.001	1935
2.3130	125	-65	0.002	1015

*Load rate too fast.

Load rate 800#/minute.

TABLE V

100% THRUST LOADS OF BEARING INSTALLED
WITH LOCTITE "B" IN STEEL BORE HOUSING HOLES
AND TESTED AT 270°F AND -65°F

Bearing Size, Dia. - Inches	Test Temp. °F	Finish, RMS	Hole Oversize, Inches	100% Load, Pounds
0.7500	270	125	0.001	425
0.7500	270	125	0.003	428
2.3130	270	125	Press Fit	2185
2.3130	270	63	0.001	885
2.3130	270	63	0.002	3160
0.7500	-65	63	Press Fit	1080
0.7500	-65	63	0.001	1085
0.7500	-65	63	0.003	680
2.3130	-65	125	0.001	3020
2.3130	-65	125	0.002	1820

Load rate 800#/minute.

TABLE VI
100% THRUST LOAD ON CONTROLS FOR IMMERSION
TEST SPECIMENS, STEEL HOUSING BORES
TESTED AT 75°F ±3°

Bearing Size, Dia. - Inches	Type Loctite	Surface Finish RMS	Hole Oversize Inches	100% Load Pounds
0.7500	-	63	Press fit	230
0.7500	A	63	0.001	630
0.7500	A	63	0.002	125
0.7500	A	63	0.003	500
0.7500	-	125	Press fit	1145
0.7500	A	125	0.002	665
0.7500	A	125	0.004	350
0.7500	A	125	0.004	160
0.7500	-	63	Press fit	239
0.7500	B	63	0.002	568
0.7500	B	63	0.002	701
0.7500	B	63	0.003	554
0.7500	-	125	Press fit	195
0.7500	B	125	0.001	635
0.7500	B	125	0.002	416
0.7500	B	125	0.003	425
2.3130	-	63	Press fit	740
2.3130	A	63	0.002	415
2.3130	A	63	0.003	205
2.3130	A	63	0.003	490
2.3130	-	125	Press fit	815
2.3130	A	125	0.002	1415
2.3130	A	125	0.002	1025
2.3130	A	125	0.003	995
2.3130	-	63	Press fit	20
2.3130	B	63	0.001	1870
2.3130	B	63	0.002	1175
2.3130	B	63	0.003	1015
2.3130	B	125	Press fit	410
2.3130	B	125	0.001	1530
2.3130	B	125	0.003	1820
2.3130	B	125	0.004	1490

TABLE VII

100% THRUST LOAD OF BEARINGS INSTALLED IN STEEL HOUSINGS
AFTER COMPLETING IMMERSION IN DISTILLED WATER
TESTED AT 75°F ±3°

Bearing Size, Dia. - Inches	Type Loctite	Surface Finish RMS	Hole Oversize Inches	100% Load Pounds
0.7500	-	63	Press fit	805
0.7500	A	63	0.001	430
0.7500	A	63	0.002	935
0.7500	A	63	0.003	850
0.7500	-	63	Press fit	527
0.7500	B	63	0.001	484
0.7500	B	63	0.002	564
0.7500	B	63	0.003	580
0.7500	-	125	Press fit	1140
0.7500	A	125	0.001	480
0.7500	A	125	0.002	510
0.7500	A	125	0.003	780
0.7500	-	125	Press fit	885
0.7500	B	125	0.003	650
0.7500	B	125	0.004	879
0.7500	B	125	0.004	983
2.3130	-	63	Press fit	1175
2.3130	A	63	0.001	705
2.3130	A	63	0.001	635
2.3130	A	63	0.002	790
2.3130	-	63	Press fit	710
2.3130	B	63	0.001	670
2.3130	B	63	0.002	830
2.3130	B	63	0.003	1215
2.3130	-	125	Press fit	2130
2.3130	A	125	0.001	1370
2.3130	A	125	0.002	710
2.3130	A	125	0.003	375
2.3130	-	125	Press fit	1120
2.3130	B	125	0.001	1130
2.3130	B	125	0.001	1625
2.3130	B	125	0.003	1240

Load Rate 800#/minute.

TABLE VIII

100% THRUST LOAD OF BEARINGS INSTALLED IN STEEL HOUSINGS
AFTER COMPLETING IMMERSION IN JP-4 FUEL
TESTED AT 75°F ±3°

Bearing Size, Dia. - Inches	Type Loctite	Surface Finish RMS	Hole Oversize Inches	100% Load Pounds
0.7500	-	63	Press fit	1170
0.7500	A	63	0.001	390
0.7500	A	63	0.002	630
0.7500	A	63	0.003	400
0.7500	-	63	Press fit	42
0.7500	B	63	0.001	796
0.7500	B	63	0.002	526
0.7500	B	63	0.003	416
0.7500	-	125	Press fit	700
0.7500	A	125	0.001	285
0.7500	A	125	0.002	875
0.7500	A	125	0.003	740
0.7500	-	125	Press fit	125
0.7500	B	125	0.001	591
0.7500	B	125	0.002	451
0.7500	B	125	0.003	653
2.3130	-	63	Press fit	340
2.3130	A	63	0.001	205
2.3130	A	63	0.002	455
2.3130	A	63	0.002	415
2.3130	-	63	Press fit	105
2.3130	B	63	0.001	1170
2.3130	B	63	0.002	1800
2.3130	B	63	0.002	1205
2.3130	-	125	Press fit	340
2.3130	A	125	0.001	810
2.3130	A	125	0.002	1250
2.3130	A	125	0.003	1795
2.3130	-	125	Press fit	150
2.3130	B	125	0.001	1810
2.3130	B	125	0.002	1075
2.3130	B	125	0.003	1390

Load Rate 800#/minute.

TABLE IX

100% THRUST LOAD OF BEARINGS INSTALLED IN STEEL HOUSINGS
AFTER COMPLETING IMMERSION IN ETHYLENE GLYCOL
TESTED AT 75° ±3°

Bearing Size, Dia. - Inches	Type Loctite	Surface Finish RMS	Hole Oversize Inches	100% Load Pounds
0.7500	-	63	Press fit	855
0.7500	A	63	0.001	385
0.7500	A	63	0.002	415
0.7500	A	63	0.003	760
0.7500	-	63	Press fit	104
0.7500	B	63	0.001	749
0.7500	B	63	0.002	840
0.7500	B	63	0.003	705
0.7500	-	125	Press fit	465
0.7500	A	125	0.001	230
0.7500	A	125	0.002	570
0.7500	A	125	0.003	655
0.7500	-	125	Press fit	934
0.7500	B	125	0.001	703
0.7500	B	125	0.002	572
0.7500	B	125	0.003	632
2.3130	-	63	Press fit	320
2.3130	A	63	0.001	410
2.3130	A	63	0.003	540
2.3130	A	63	0.003	815
2.3130	-	63	Press fit	460
2.3130	B	63	0.002	690
2.3130	B	63	0.002	710
2.3130	B	63	0.003	1750
2.3130	-	125	Press fit	410
2.3130	A	125	0.001	905
2.3130	A	125	0.002	675
2.3130	A	125	0.003	1435
2.3130	-	125	Press fit	885
2.3130	B	125	0.001	1235
2.3130	B	125	0.002	1815
2.3130	B	125	0.004	1455

Load Rate 800#/minute.

TABLE X

100% THRUST LOADS OF BEARINGS INSTALLED IN STEEL HOUSINGS WITH LOCTITE "A" USING DIFFERENT CLEANING METHODS (TESTED AT 75°F ±3°)

Bearing Size (inches)	Cleaner	Finish (RMS)	Oversize (inches)	100% Load (pounds)
2.3130	Acid	125	0.002	2815
2.3130	Sand blast	63	0.002	4125
2.3130*	Acid	63	-	2075
2.3130*	Acid	63	-	1540
2.3130*	Acid	63	-	2125
2.3130*	Sand blast	63	0.001	3340
2.3130*	Sand blast	63	0.001	2485
2.3130*	Sand blast	63	0.002	1645
2.3130*	Sil Sol	63	0.002	1875
2.3130*	Sil Sol	63	0.002	1235
2.3130	Sand blast	63	0.001	3685
2.3130	Sand blast	63	0.001	3265
2.3130	Sand blast	63	0.003	3495
2.3130	Acid	63	0.001	2215
2.3130	Acid	63	0.002	1170
2.3130	Acid	63	0.005	3585
2.3130	Sil Sol	63	0.001	1230
2.3130	Sil Sol	63	0.003	1210

*Cured at 250°F for 30 minutes.

Load rate 800#/minute.

Figure 1

A. Bearings to be used will be:

G.D. #	Vendor #
C4-1263-3-1	(MKS4A)
C4-1263-25-1	(MKP25B)

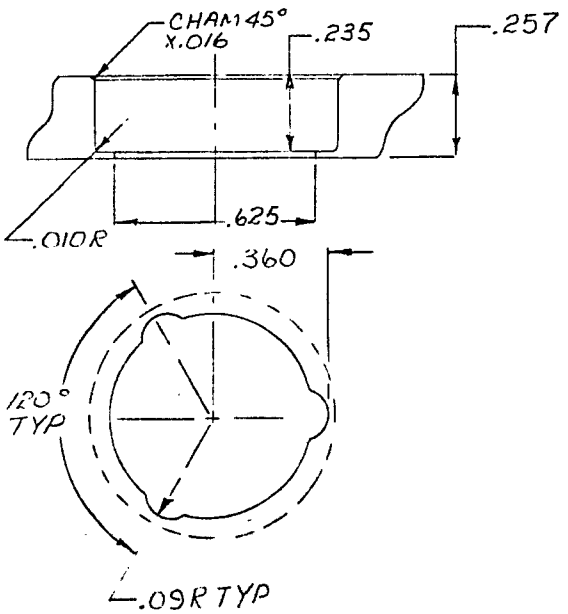
These bearings were selected because they best represent the various bearings used in the flight control system.

B. Bore hole sizes to be used are:

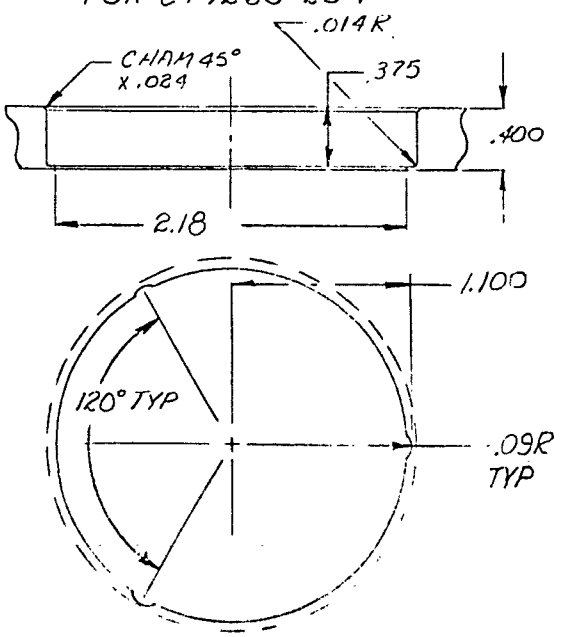
For C4-1263-3-1	C4-1263-25-1
1) .7497" $^{+.0000"}_{-.0005"}$	1) 2.3125" $^{+.0000"}_{-.0010"}$
2) .750" $^{+.000"}_{-.001"}$	2) 2.313" $^{+.000"}_{-.001"}$
3) .750" $^{+.000"}_{-.002"}$	3) 2.313" $^{+.000"}_{-.002"}$
4) .750" $^{+.000"}_{-.003"}$	4) 2.313" $^{+.000"}_{-.003"}$

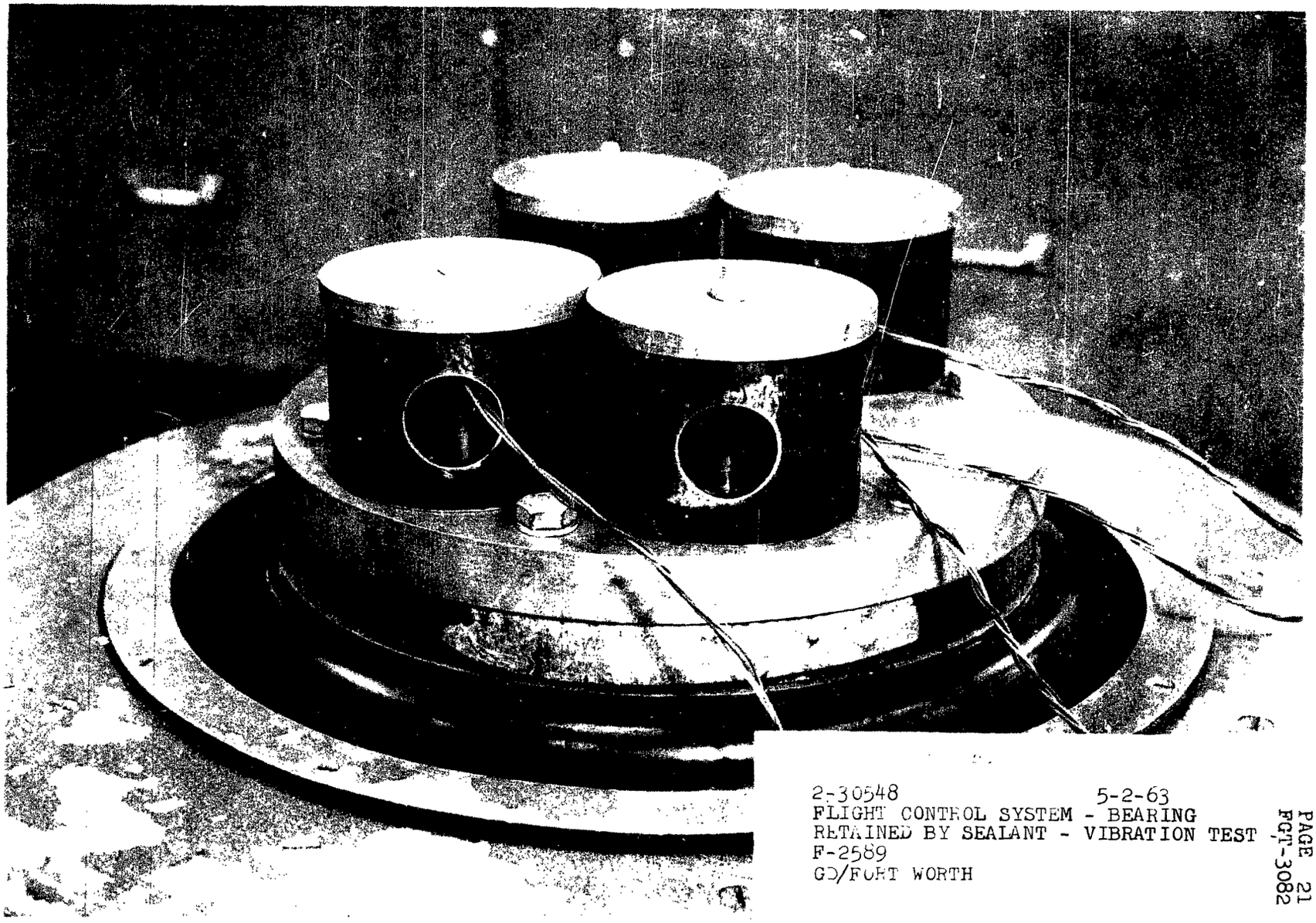
TYPICAL INSTALLATION DIAGRAMS

FOR C4-1263-3-1 (TWICE SIZE)

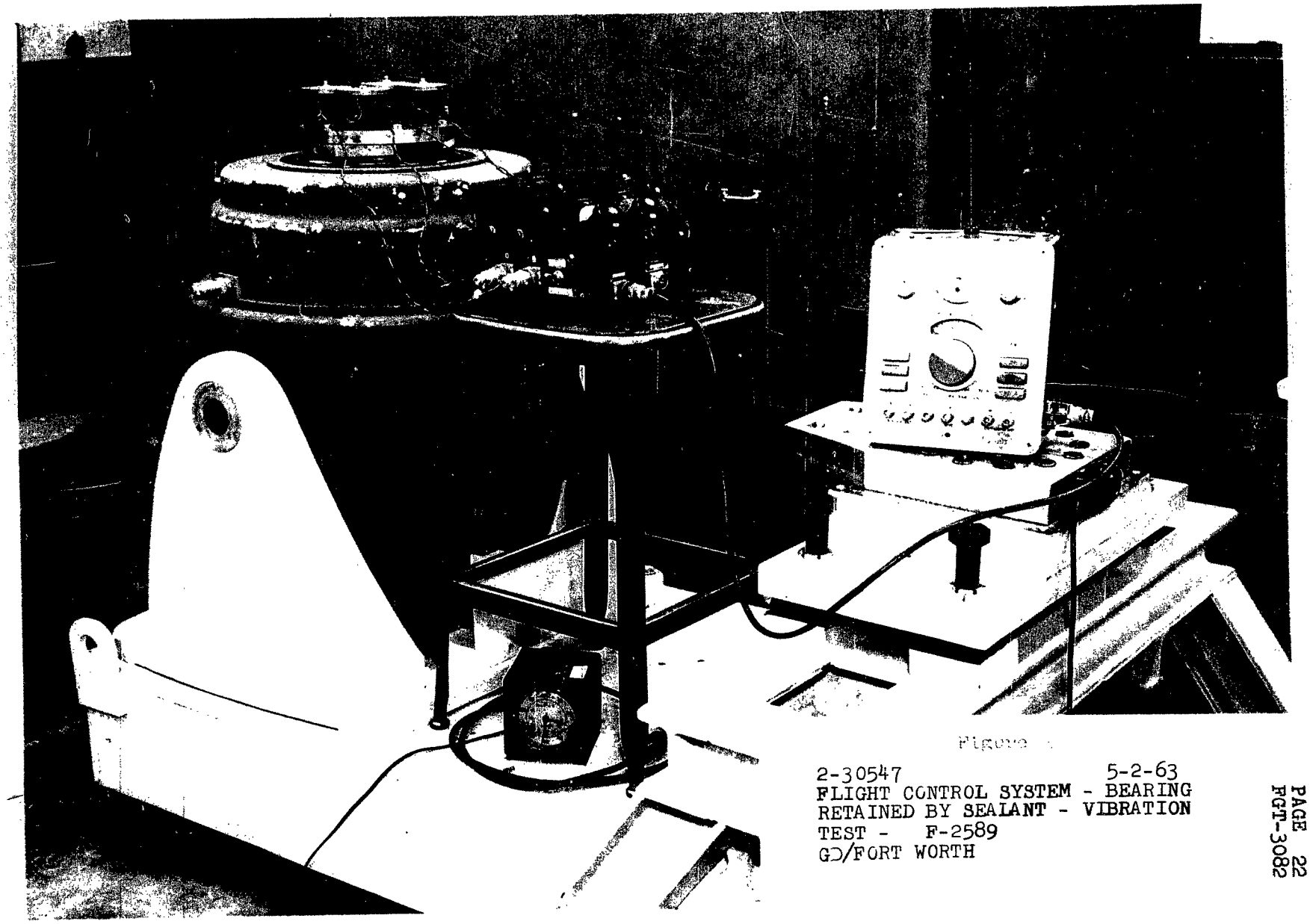


FOR C4-1263-25-1





2-30548 5-2-63
FLIGHT CONTROL SYSTEM - BEARING
RETAINED BY SEALANT - VIBRATION TEST
F-2589
GD/FORT WORTH



Figure

2-30547 5-2-63
FLIGHT CONTROL SYSTEM - BEARING RETAINED BY SEALANT - VIBRATION TEST - F-2589
GD/FORT WORTH

Taken from Report FZM-12-104A, dtd. 11 June 1963, page 49.

VIBRATION TEST SCHEDULE

Number of Resonance	0	1	2	3	4
Total Vibration Time at Resonance*	--	30 min.	1 hr.	1 1/2 hrs	2 hrs
Cycling Time	3 hrs	2 1/2 hrs	2 hrs	1 1/2 hrs	1 hr

* 30 minutes at each resonance

Taken from page 82 of same report as above. Test temperature was in a range from -65 to 270°F.